CALIFORNIA DEPARTMENT OF WATER RESOURCES

Levee Analysis Methods

FloodSAFE VISION

A sustainable integrated flood management and emergency response system throughout California that improves public safety, protects and enhances environmental and cultural resources, and supports economic growth by reducing the probability of destructive floods, promoting beneficial floodplain processes, and lowering the damages caused by flooding.

FloodSAFE CALIFORNIA

Reflecting Governor Arnold Schwarzenegger's long-term commitment to improving flood safety to prevent possible catastrophic flooding and loss of life, the California Department of Water Resources (DWR) is undertaking unprecedented efforts to evaluate and upgrade levees in the Sacramento and San Joaquin River Flood Control Systems as well as the Delta.

Of highest priority, DWR is fully evaluating more than 470 miles of urban levees and 1,620 miles of non-urban levees in the Central Valley. Funding for the levee evaluation efforts is provided through Proposition 1E, approved by California voters in 2006.

As an essential first step in providing improved flood protection for Central Valley communities, DWR is conducting geotechnical exploration, testing, and analysis of levees that protect the highly populated urban areas of greater Sacramento, Stockton/Lathrop, and Marysville/Yuba City, followed by evaluation of levees that protect non-urban areas. This program is being implemented concurrently with many urgent levee repairs.

To expedite improved management of flood risk, DWR is conducting levee evaluations in phases over a four to six-year period. During this time, technical specialists are reviewing existing levee historical data; conducting field explorations (including drilling and geophysical methods) and associated laboratory testing; performing geotechnical engineering analyses; and preparing preliminary design and construction estimates for levee repairs and upgrades, where needed

Throughout the Central Valley, levees provide essential protection for communities and farmland, preventing possible catastrophic flooding and loss of life. DWR is currently evaluating approximately 2,100 miles of Central Valley levees as shown above.

Levee Analyses

Levee analyses consider both past and future (projected) performance of flood control levees in terms of seepage, stability, erosion, settlement, and seismic factors. To get a detailed picture of the flood control system's current condition, experts study a wide range of critical levee properties, including:

- Geomorphology
- Levee topography
- Subsurface condition
- Historical events
- Levee materials and construction
- Erosion conditions

Preliminary analytical results for levees protecting urban areas are also being reviewed by an independent panel of levee experts, the U.S. Army Corps of Engineers, and local agencies.

For additional information, including repair and survey locations and other levee information, please visit *www.water.ca.gov/levee* or e-mail *leveerepair@water.ca.gov*

Evaluation Methods

In addition to the basic geotechnical evaluation program of drilling and boring to collect levee soil samples, other proven methods and innovative technologies are being used to develop a comprehensive understanding of the levees' existing subsurface conditions. These methods include regional geomorphologic assessments, detailed mapping of geomorphic features and surficial geologic deposits, Light Detection and Ranging topographic surveys, geophysical electromagnetic and galvanic surveys, and underwater bathymetric surveys. Data collected from these and other methods is used to cumulatively assess the levees' structural integrity and identify which areas are most in need of critical improvements or repairs.

Geotechnical Exploration

Much of the evaluation of levees and their foundations is done by relatively straightforward methods (e.g., drilling) to collect soil samples, which are then analyzed to assess subsurface conditions. Cone penetrometer testing is also utilized. In urban areas, ongoing subsurface explorations are typically conducted at 1,000-foot intervals along the levees, with additional explorations on the landside of levees. Subsurface explorations for non-urban areas will typically be performed at intervals greater than 1,000 feet. Looking closely at subsurface soil conditions—such as moisture, density, and soil grain-size distribution—helps identify potential problems or weaknesses in the levees.

Geomorphologic Assessments

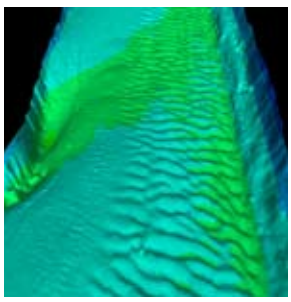
By studying the evolution of landforms and the processes that alter them, scientists can better assess levee stability and understand the materials beneath levees. For the levee evaluation program, experts are preparing a comprehensive surficial geomorphic map of project areas, based on field reconnaissance observations and review of vintage aerial photos and topographic maps, geologic maps, and satellite imagery. Results of this effort will lead to a better understanding of materials directly beneath existing levees and of the geomorphic processes (e.g., erosion, deposition) responsible for those materials.

Light Detection and Ranging Topographic Surveys

Light Detection and Ranging (LiDAR) technology deployed in low-flying helicopters was used to electronically gather data about the topography and configuration of Central Valley flood control levees. Airborne LiDAR produces accurate elevation models for terrain, which supports evaluation of geotechnical and erosion characteristics of the surveyed levees. In spring 2007, helicopters equipped with LiDAR performed aerial topographic surveys over approximately 500 miles of levees stretching from Oroville to Lathrop. Additional flights with fixed-wing aircraft were flown throughout the Central Valley in March 2008.

Electromagnetic Surveys

Another way to evaluate levee subsurface conditions is by conducting geophysical electromagnetic (EM) surveys. Like LiDAR, this technology is deployed during helicopter flights over the levees. An EM survey sensor, which resembles an airborne torpedo, is suspended from the helicopter about 100 feet above the levees. The EM technology senses variations in the ground's electrical conductivity to depths greater than 100 feet. The goal is to map important changes in soil types and ground conditions, identifying zones where permeable soils are present or excessive water penetration is taking place. DWR conducted these surveys in late summer 2007 along more than 200 miles of levees on the Feather River, Bear River, American River, Sutter Bypass, Yolo Bypass, Sacramento River, Stanislaus River, San Joaquin River, and tributaries.



Bathymetric Surveys

Bathymetric surveys are underwater explorations conducted by boats equipped with either a single-beam or special multi-beam sonar device. These surveys produce detailed topographic data of the riverbed and riverbanks that essentially form the base of levee systems. Collected data yield an image of the levees' underwater structure that cannot be obtained by conventional land topographic methods. The data are especially important in revealing underwater erosion of the riverbanks. Bathymetric surveys were conducted in late 2007 and early 2008 along parts of the Sacramento, American, San Joaquin, and Calaveras Rivers. Future surveys are planned in non-urban areas. Bathymetric survey data supplements above-water topographic data collected during LiDAR surveys; together, this information supports geotechnical evaluation of the levees.